(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 762 535 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.03.1997 Bulletin 1997/11

(21) Application number: 96113479.8

(22) Date of filing: 22.08.1996

(51) Int. Cl.[6]: H01Q 7/06, H01Q 21/28, G01S 13/02, H01Q 25/00, H01F 1/153

(84) Designated Contracting States:
DE FR GB

(30) Priority: 22.08.1995 JP 213353/95
05.07.1996 JP 176543/96
05.07.1996 JP 176544/96

(71) Applicant: MITSUBISHI MATERIALS CORPORATION
Chiyoda-ku, Tokyo (JP)

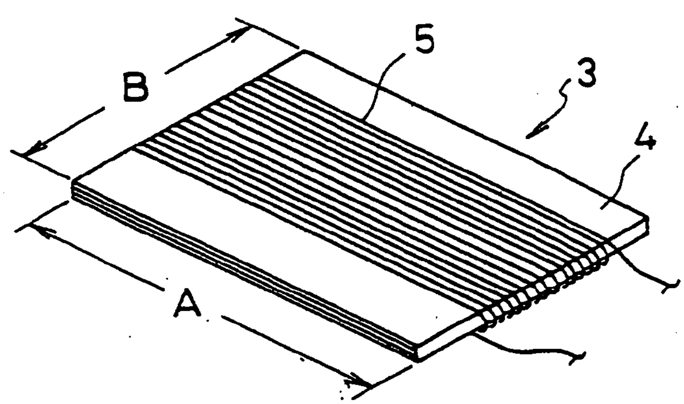
(72) Inventors:
- Yahata, Seiro
Chiyoda-ku, Tokyo (JP)
- Endo, Takanori,
c/o Mitsubishi Materials Corp.
Omiya-shi, Saitama-ken (JP)
- Miyake, Masami,
c/o Mitsubishi Materials Corp.
Omiya-shi, Saitama-ken (JP)
- Tsuchida, Takashi,
c/o Mitsubishi Materials Corp.
Omiya-shi, Saitama-ken (JP)

(74) Representative: Müller-Boré & Partner
Patentanwälte
Grafinger Strasse 2
81671 München (DE)

(54) Antenna for transponder and transponder

(57) An antenna for a transponder comprises a magnetic core composed of layered amorphous metallic thin plates or composite plates of soft magnetic flakes and a synthetic resin, and a coil wound on the magnetic core. A transponder comprises two antennas set forth above, and a spiral antenna.

FIG. 1



EP 0 762 535 A1

Description

The present invention relates to antennas for transponders and to transponders. In particular, the present invention relates to an antenna for a transponder and a transponder operating at a frequency of 40 kHz to 200 kHz, or at a frequency exceeding 100 kHz, which is suitable for the usage of such an apparatus carried on a person, such as ID cards, commuter passes and coupon tickets.

Antennas which have used include those of a winding on a ferrite magnetic core, and those of a wound conductor without a magnetic core. In antennas used in alternate magnetic fields, the use of the magnetic core comprising layered thin plates prevents a loss due to eddy currents (i.e. an eddy current loss).

When a prior art antenna is used for the transponders carried on persons for ID cards, commuter passes and coupon tickets, the following problems arise.

Because ferrite is hard, not flexible, and thus fragile on bending, it is not suitable for being carried in a pocket.

Although a coil not having a magnetic core can be thinned by forming a concentric spiral coil 1 as shown in FIG. 2A, the coil characteristics are weakened, disturbed, interfered or deteriorated when a coin 10 or the aluminum foil in a cigarette case in a person's pocket overlaps perpendicularly with the axis of a transponder 2 having such a coil 1 as shown in FIG. 2B. Such a characteristic deterioration can be prevented with significant inconvenience by taking out the transponder from the pocket when using it. Further, such a use may cause the deterioration of characteristics due to attached water drops or snow.

When a metallic magnetic core is used with an alternate current, the eddy current loss has been prevented by layering thin magnetic plates having high electric resistance while insulating the plates from each other. Such an effect is more enhanced with a higher electric resistance and a smaller thickness of the magnetic material. However, already at a frequency exceeding a few dozen kHz, and in particular, more than a hundred kHz, a significant loss is caused and thus it is not suitable for use even if a material is used which has an extremely high electric resistance and an extremely small thickness and is industrially available, i.e. an amorphous metal having an electric resistance of 137 $\mu\Omega$cm and a thickness of 23 μ.

It is an object of the present invention to provide an antenna for a transponder and a transponder making use of such an antenna, which is thin and flexible, has a small loss including eddy current loss at a high frequency, and is essentially not affected by a coin or an aluminum foil in a cigarette case or other ferrous or non-ferrous metal materials possibly carried close to the transponder like keys of cars or house doors.

An antenna for a transponder in accordance with a first embodiment of the present invention comprises a magnetic core composed of layered rectangular metallic thin plates, and a coil wound parallel to the longer side of the magnetic core.

Because the magnetic core in such an antenna for a transponder is composed of layered metallic thin plates, the antenna is thin and flexible, and has a decreased high-frequency loss. By winding a coil in the longer side direction of the magnetic core in a preferred embodiment, the loss is even more significantly decreased at high frequency regions over a few dozen kHz.

When the antenna is mounted in a transponder, the magnetic flux flows parallel to the transponder's plane. Thus, the magnetic flux is essentially not affected by a coin or an aluminum foil or other ferrous or non-ferrous metal materials like used for keys of cars or house doors overlapping in the transponder's plane.

A transponder in accordance with a second embodiment of the present invention has two plate antennas each comprising a magnetic core composed of layered metallic thin plates around which a conductor coil is wound, and an air-core antenna composed of a spirally wound conductor.

An antenna for a transponder in accordance with a third embodiment of the present invention comprises a plate magnetic core composed of a composite material of magnetically soft flakes and a synthetic resin, and a coil wound around such a magnetic core.

Such an antenna for a transponder is thin and flexible and has a decreased high-frequency loss, because the magnetic core is composed of a composite material of a magnetically soft flake and a synthetic resin.

When the antenna for the transponder is fabricated in a transponder, the magnetic flux flows parallel to the transponder plate or plane. Thus, the magnetic flux is nearly not affected by a coin or an aluminum foil or similar material overlapping the transponder plate.

A transponder in accordance with a fourth embodiment of the present invention comprises two plate antennas in accordance with the third embodiment set forth above, and an air-core antenna composed of a spirally wound conductor.

FIG. 1 is a perspective view illustrating an antenna in accordance with an embodiment of the present invention;

FIG. 2A is a plan view illustrating a transponder having a prior art antenna and FIG. 2B is a perspective view of the same;

FIGs. 3A and 3B are plan views illustrating a magnetic core in accordance with an embodiment of the present invention;

FIG. 4A is a plan view illustrating a transponder in accordance with an embodiment of the present invention and FIG. 4B is a side view of the same;

FIG. 5A is a plan view illustrating a transponder also usable as a magnetic card and FIG. 5B is a side view of the same;

FIGs. 6A and 6B are representative views illustrating the length, width and thickness of coils in Example (6A) and Comparative Example (6B); and

FIG. 7A is a plan view illustrating a transponder in accordance with an embodiment of the present invention, and FIG. 7B is a side view of the same.

An antenna for a transponder in accordance with a first embodiment of the present invention will now be explained.

FIG. 1 is a perspective view illustrating a prefered feature of an antenna 3 in accordance with the first embodiment of the present invention.

This antenna 3 comprises a magnetic core 4 composed of layered metallic thin plates, and a coil 5 wound thereon.

Preferred materials for the metallic thin plates are magnetically soft materials, and in particular, of having excellent magnetic properties and a large specific resistance, i.e. a large, resistivity. Examples of such materials include amorphous magnetic materials, such as METAGLAS 2714A (Co-Fe-Ni-B-Si type), 2605S2 (Fe-B-Si type), 2605SC (Fe-B-Si-C type) and 2876MB (Fe-Ni-Mo-B type) made by Allied Signal; iron-nickel alloys, such as JIS 2531 PB PC; silicon steels, such as JIS 2553 Z6H and RC6HL G09 S09; and the like. Among them, Co-Fe-Ni-B-Si-type amorphous magnetic material is more preferred, and the preferable thickness of the metallic thin plates range from 20 to 50 μm.

The number of the layered metallic thin plates is preferably 3 to 16. Although only metallic thin plates can be layered without inserting other material, metallic thin plates which are insulated by coating or oxidizing their surfaces also may be layered. Further, in order to secure the insulation between the metallic thin plates, an insulating material, such as paper and polymeric films may be inserted between the metallic thin plates in the layering.

The ratio B/A of the side length B to the side length A in the magnetic core 4 composed of layered metallic thin plates is 1 or, preferably less than 1 and, more preferably 0.4 to 1.0, and even more preferably 0.5 to 0.9.

The conductor wound as the coil 5 is preferably 100 to 200 μm in diameter. When the coil 5 is formed, the conductor is wound around the magnetic core 4 in the direction parallel to its long side. The prefered thickness of the antenna 3 after the coil is wound around it is 0.4 mm or less, and more prefered 0.3 mm or less.

The cross-section of the conductor of the coil 5 is typically circular, and is preferably rectangular for the more compact coil. Suitable materials for the conductor are pure copper for general use, chromium copper for a use requiring particular strength for higher vibration resistance, highly conductive silver for more compact size, corrosion resistive gold for the use requiring high reliability, and aluminum for lighter weight.

The magnetic core of the antenna in accordance with the present invention is flexible to prevent breakage due to bending. Further, because the antenna is thin and the coil axis can be set to be parallel to the transponder plate, its characteristics are nearly not affected or deteriorated when a coin or aluminum foil or other ferrous or non-ferrous metal materials overlaps with the transponder. Thus, the antenna has a small loss at high frequencies. The term loss used in the specification includes eddy current loss.

In particular, when the corners of the magnetic core are cut or rounded as shown in FIGS. 3A and 3B on examples described later, the loss can be further suppressed at high frequencies. The loss in the antenna in accordance with the present invention, of which the coil is wound around the magnetic core composed of layered metallic thin plates in the longer side direction, is significantly lowered at a high frequency region of a few dozen kHz, and the most of the loss is generated at the corners of the magnetic core. Thus, the corners are cut or rounded like the magnetic core 3A shown in FIG. 3A or the magnetic core 3B shown in FIG. 3B, respectively, to decrease the loss.

When the corners are cut, the length of the cut side (a in FIG. 3A) is generally 2 to 12 mm, preferably 3 to 10 mm, and more preferably 4 to 8 mm. When the corners are rounded, the curvature radius R is generally 2 to 15 mm, preferably 3 o 12 mm, and more preferably 4 to 10 mm.

Next, a transponder of a second embodiment using the antenna in accordance with the present invention will be explained.

The transponder in accordance with the present invention is produced by embedding the antenna 3 for transponder as well as a circuit chip into a synthetic resin. The preferred size of the transponder is 54 mm in width and 86 mm in length similar to credit cards generally used. A size larger than this is too bulky to carry, whereas a size less than this often causes the loss, the both resulting in inconvenient handling. The preferred thickness of the transponder is 0.76 mm or less similar to credit cards.

As shown in FIGS. 4A and 4B, plate transponder 8 in accordance with the present invention is provided with two thin plate antennas 6, 7, while their coil axes (or antenna axes) are perpendicular to each other, and an air-core antenna composed of an air-core spiral coil 9 is provided in the transponder 8, so that the axis is perpendicular to the transponder plate. Axes of the antennas 6, 7 and of the antenna composed of the coil 9 are preferably directed to three directions perpendicular to each other. These antennas have chip circuits 11.

When a transponder is used as an ID card or a commuter pass to be carried in a pocket and effective on an auto-

mated wicket, such a transponder must respond to radio waves from any directions, because there is no correlation of the directions between the antenna of an interrogating transmitter, interrogator or receiver and the transponder defined. Although a plate transponder having two plate antennas with their axes crossing in the plane of said plate can respond to all the directions parallel to the plate, such a transponder cannot respond to directions in the plane perpendicular to the plate. The above described spiral antenna cannot respond to directions parallel to the plate.

The inventive plate transponder shown in FIGs. 4A and 4B can respond to radio waves of an interrogator from all directions, regardless of the direction of the transponder to the direction of said radio waves relation; the antenna 7 responds to radio waves in the X direction, the antenna 6 responds to radio waves in the Y direction, and the air-core antenna (coil) 9 responds to radio waves in the Z direction.

The transponder 12 shown in FIGs. 5A and 5B may be provided with a magnetic recording layer, such as a magnetic stripe 13, at the surface, and the antenna 14 in accordance with the present invention. The transponder can be used in both the contact and non-contact states. Any printing 15 may be applied on the surface without magnetic recording for the visual judgement. Any embossment can be formed at the sections other than the antenna, circuit and magnetic recording layer for clearer printing and improving the durability against rewrite and wear. The transponder 12 has a circuit chip 16.

An antenna for a transponder in accordance with a third embodiment will now be explained.

Examples of magnetically soft materials used for the flakes of a composite material suitable as a magnetic core for the antenna of the transponder in accordance with a third embodiment of the present invention include pure iron, silicon steel, permalloys (Fe-Ni alloy), iron/cobalt amorphous alloys, and in particular, cobalt amorphous alloys (Co-Fe-Ni-B-Si). Amorphous alloys have excellent highfrequency characteristics, and are readily formed to flakes by striking to quench the molten drops from the molten alloy flow on the copper surface cooled with water.

The thickness of the flakes is preferably 30 μm or less, and more preferably 10 μm or less, to prevent the effect of eddy currents, i.e. eddy current loss. A larger flake diameter can increase the permeability of the composite material and decrease the magnetic core size. However, an excessively large diameter of the flakes barely homogenizes the magnetic core material. Accordingly, the flake diameter ranges 50 to 2,000 μm, and preferably 100 to 1,000 μm.

Examples of synthetic resins include thermoset resins, e.g. epoxy resins, phenol resins, urea resins, unsaturated polyester resins, diacrylphthalate resins, melamine resins, silicone resins, and polyurethane resins; and thermoplastic resins, e.g. polyethylene resins, polypropylene resins, vinyl chloride resins, fluoroplastics, methacrylate resins, polystyrene resins, AS resins, ABS resins, ABA resins, polycarbonate resins, polyacetal resins, and polyimide resins.

The flexibility of the composite material increases and the shaping characteristics improve with the increased synthetic resin content in the composite material. When the resin content is too small, the strength of the composite material decreases. On the other hand, an excessive synthetic resin content causes a decrease in permeability. Accordingly, the prefered amount of the synthetic resin is 3 to 50 weight%, and more preferably 10 to 40 weight% of the composite material.

Usable molding methods include injection molding, compression molding, rolling, and doctor blade shaping. A composite material having excellent magnetic characteristics can be obtained by compression molding, rolling or doctor blade shaping, since the flake plane is oriented to the plane of the composite material. The size suitable to carrying out such a method is 0.3 to 2 mm in thickness, 100 mm or less in width and length, and in particular, 0.3 to 1 mm in thickness, 10 to 25 mm in width, and 60 to 80 mm in length.

When the conductor forming the coil is too thick, the antenna becomes too thick, whereas the excessively thin conductor causes an increase in resistance. Thus, the diameter of the conductor preferably ranges from 100 to 200 μm.

It is preferred that the coil is wound perpendicular to the longer side of the antenna, in other words, the coil axis is parallel to the longer side.

The antenna for the transponder in accordance with the present invention exhibits excellent effects in that the antenna is thin and flexible, the loss is low at high frequencies over 100 kHz, and the antenna is less affected by a coin or aluminum foil package or other ferrous or non-ferrous metal materials.

A transponder using an antenna in accordance with a fourth embodiment of the present invention will now be explained in reference to FIGs. 7A and 7B.

In this transponder, two plate antennas in accordance with the third embodiment are placed perpendicular to each other, and an air-core antenna composed of a spirally wound conductor is placed, similar to the second embodiment set forth above, because the direction of the transponder antenna is not always oriented in the direction of the magnetic flux of the interrogating machine when the transponder in the pocket passes through an automatic wicket. As shown in FIGs. 7A and 7B, two thin plate antennas 26, 27 in accordance with the present invention are provided in the plate transponder 28 with their axes crossing in the plane of the plate transponder and an air-core antenna composed of an air-core spiral coil 29 is provided in the plate transponder 28 so that the axis of the antenna is perpendicular to the plate of the transponder. Axes of the antennas 26, 27 and of the antenna composed of the coil 29 are preferably directed to three directions perpendicular to each other. These antennas have chip circuits 31.

When the transponder is used as an ID card or a communter pass to be carried in the pocket and effective on an automatic wicket, there is no correlation between the direction of the interrogator antenna and the direction of the trans-

ponder defined. Thus, the transponder must respond to radio waves from all the directions. A transponder, which has two plate antennas crossing each other, can respond to the direction parallel to the plate, but cannot respond to the direction perpendicular to the plate. On the other hand, the plate transponder shown in FIGs. 7A and 7B can respond to waves from all the directions, regardless of the direction of the transponder; the antenna 27 responds to radio waves in the X direction, the antenna 26 responds to radio waves in the Y direction, and the air-core antenna (coil) 29 responds to radio waves in the Z direction.

Experiment 1

A sheet composed of Allied Signal METAGLAS 2714A having a width of 50 mm and a thickness 25 μm was used as a magnetic core material. The sheet was cut into a size shown in Table 1, was heated at 250°C for 10 min. in air, and quenched. A magnetic core was produced by layering a few sheets so as to reach the thickness shown in Table 1. An insulation conductor having a diameter of 0.15 mm was wound around the magnetic core so that the inductance L of the coil is approximately 3 mH. The conductor was wound in the direction parallel to the longer side of the magnetic core in Examples, and in the direction parallel to the shorter side of the magnetic core in Comparative Examples.

The resistance of each antenna due to the magnetic core was evaluated by the following equation from the resistance R obtained from Yokogawa-Hewlett-Packard LCR meter 4284A:

$$R1 = R - R2$$

wherein R1 represents a resistance due to the magnetic core, R represents an observed resistance, and R2 represents a direct current resistance of the coil.

Results are shown in Table 1. Table 1 evidently demonstrates that the resistance significantly decreases by winding the coil in the direction parallel to the longer side of the magnetic core.

As shown in FIGs. 6A and 6B, the magnetic core size perpendicluar to coil axis is represented by A, the magnetic core size parallel to the coil axis is represented by B, and the magnetic core size perpendicular to the plane AB is represented by C.

(Table 1)

	Magnetic Core Size				Resistance due to Magnetic Core R_1 (Ω)								
	A (mm)	B (mm)	C (μ)	B/A	30 kHz	40 kHz	50 kHz	60 kHz	80 kHz	100 kHz	120 kHz	150 kHz	250 kHz
Examples	50	15	300	0.3	1.5	2.1	3.8	5.9	10.3	16.5	24.4	40.8	84.3
	50	20	300	0.4	2.3	4.1	5.8	8.5	14.7	23.0	26.4	48.2	98.8
	50	25	75	0.5	2.3	4.3	6.7	9.7	17.2	26.0	38.9	60.8	108
	50	25	150	0.5	2.4	4.8	7.3	10.1	17.5	26.8	37.8	56.2	106
	50	25	300	0.5	2.7	4.7	6.6	9.2	15.8	24.1	33.8	52.3	96.3
	50	25	600	0.5	2.7	4.8	6.4	8.6	14.9	23.5	32.4	49.6	92.3
	50	35	300	0.7	5.9	10.4	16	23.3	42.8	70.9	114	224	840
	50	50	300	1.0	9.9	17.7	28.2	41.6	77.5	134	224	480	2500
Comparative Examples	50	75	300	1.5	10.8	25.1	38.0	80.7	103	162	281	816	4250
	50	100	300	2.0	12.7	28.8	48.9	72.5	115	194	335	910	5650
	50	200	300	4.0	16.6	30.1	59.7	94.3	140	253	440	1030	7400

Remarks A: Magnetic core size perpendicular to coil axis
B: Magnetic core size parallel to coil axis
C: Thickness

Experiment 2

A sheet composed of Allied Signal METAGLAS 2714A having a width of 50 mm and a thickness 25 μm was cut into 50 mm by 25 mm. Four corners of the cut sheet in Example A were cut as shown in FIG. 3A (a = 6 mm). Four corners of the cut sheet in Example B were rounded as shown in FIG. 3B so as to form arcs (R = 6 mm). Each corner in Example C was maintained to right angle. Sheets were heated at 250°C for 10 min. in air, and quenched. A magnetic core of each Example was produced by layering three sheets. An insulation conductor having a diameter of 0.15 mm was wound up twice by each 85 turns in the direction parallel to the longer side of the magnetic core to form an antenna. The direct current resistance of the coil was 20.4 Ω.

The resistance of each antenna due to the magnetic core was evaluated similar to Experiment 1. Results are shown in Table 2. Table 2 demonstrates that the resistance significantly decreases by eliminating the corners of the magnetic core.

(Table 2)

Frequency (kHz)	Example A Core with Cut Corner (Ω)	Example B Core with Rounded Corner (Ω)	Example C Core without Corner Treatment (Ω)
30	2.1	2.2	2.7
40	3.7	3.8	4.4
50	3.5	3.7	4.8
60	5.7	6.0	7.8
80	13.9	14.5	17.6
100	23.7	24.7	29.4
120	37.7	39.2	46.6
150	54.1	56	65.8
200	108.6	112.3	134.1

Experiments 3

(Example)

A sheet composed of Allied Signal METAGLAS 2714A having a width of 50 mm and a thickness 0.025 mm was cut into 50 mm by 25 mm, heated at 250°C for 10 min. in air, and quenched. A magnetic core was produced by layering three sheets. An insulation conductor having a diameter of 0.16 mm was wound up by 180 turns in the direction parallel to the longer side of the magnetic core.

(Comparative Example)

On the other hand, an antenna composed of an air-core coil of which a conductor having a diameter of 0.016 mm was wound by 400 turns.

(Measurement)

The resistance of magnetic core of each sample, of which a 10-yen coin was placed in the coil center as shown in FIG. 2B, was measured similar to Experiments 1 and 2. Results are shown in Table 3. Table 3 evidently demonstrates that the antenna of Example exhibits a smaller resistance in a practical frequency region as a transponder of 40 to 200 kHz.

(Table 3)

Frequency (kHz)	Example Coil with Core Core Diameter 0.16 mm Number of Turns 180 (Ω)	Comparative Example Air-core Coil Conductor Diameter 0.16 mm Number of Turns 400 (Ω)
30	6.2	20.0
40	8.8	23.3
50	11.6	26.4
60	14.8	29.5
80	21.7	35.3
100	29.9	41.2
120	39.0	47.1
150	55.6	56.3
200	70.0	73.1

Experiment 4

(Examples)

No. 1

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 5 μm and an average diameter of 500 μm with an epoxy resin in an amount of 10% (the rate of the resin to the total of the flake and resin) and by compression-molding at 160°C and 200 kg/cm^2. The magnetic core material was cut into cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

No. 2

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 5 μm and an average diameter of 500 μm with an epoxy resin in an amount of 20% (the rate of the resin to the total of the flake and resin) and by compression-molding at 160°C and 200 kg/cm^2. The magnetic core material was cut into cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

No. 3

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 5 μm and an average diameter of 500 μm with an epoxy resin in an amount of 30% (the rate of the resin to the total of the flake and resin) and by compression-molding at 160°C and 200 kg/cm^2. The magnetic core material was cut into cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

No. 4

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 5 μm and an average diameter of 500 μm with an epoxy resin in an amount of 40% (the rate of the resin to the total of the flake and resin) and by compression-molding at 160°C and 200 kg/cm^2. The magnetic core material was cut into

cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

No. 5

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 5 µm and an average diameter of 300 µm with an epoxy resin in an amount of 20% (the rate of the resin to the total of the flake and resin) and by compression-molding at 160°C and 200 kg/cm^2. The magnetic core material was cut into cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

No. 6

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 10 µm and an average diameter of 500 µm with an epoxy resin in an amount of 20% (the rate of the resin to the total of the flake and resin) and by compression-molding at 1 60°C and 200 kg/cm^2. The magnetic core material was cut into cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

No. 7

A magnetic core material was prepared by mixing Co-type amorphous metal flakes having an average thickness of 5 µm and an average diameter of 500 µm with a mixture of an urethan resin and an epoxy resin in an amount of 20% (the rate of the resin mixture to the total of the flake and resin mixture) and by compression-molding at 160°C and 200 kg/cm^2. The magnetic core material was cut into cut sheets having a thickness of 0.6 mm, a width of 25 mm, and a length of 80 mm. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

(Comparative Examples)

No. 1

A magnetic core material was prepared by cutting Allied Chemical METAGLAS 2714A into a rectangular pieces having a width of 25 mm and a length of 50 mm. A magnetic core having a thickness of 0.3 mm was produced by layering 12 pieces. A conductor having a diameter of 0.15 mm was wound in the direction parallel to the cut sheet so that L is 3 mH.

(Measurement)

The resistance R (loss) of each coil was measured with a Yokogawa-Hewlett-Packard LCR meter. Results are shown in Table 4.

Table 4 evidently demonstrates that the antenna in accordance with the present invention exhibits a small loss in a high frequency region over 100 kHz.

(Table 4)

Frequency kHz	Resiostance R (Ω)							
	Example No. 1	Example No. 2	Example No. 3	Example No. 4	Example No. 5	Example No. 6	Example No. 7	Comp. Ex. No. 1
50	29.3	30.8	31.3	32.7	31.0	30.8	30.7	23.7
80	29.5	31.0	31.8	32.3	31.4	31.6	31.4	26.1
100	29.8	31.3	32.8	33.1	31.9	30.7	31.3	29.4
120	33.4	33.4	33.5	33.4	33.3	33.7	33.2	46.6
150	38.1	36.6	38.9	38.6	39.1	39.4	38.9	65.8
200	76.6	54.3	48.8	43.5	54.9	57.0	53.6	134.1
250	125.0	73.0	85.7	61.6	73.8	80.3	71.9	201.2
300	193.3	110.1	106.8	80.9	110.7	132.1	113.1	301.7
400	395.0	271.6	121.5	87.0	274.1	353.1	271.0	452.6
500	1243.3	914.3	583.9	413.6	913.5	1280.0	936.4	1678.9

Claims

1. An antenna (3; 6, 7, 9; 14; 26, 27, 29) for a transponder (8; 12; 28) comprising a magnetic core (4) composed of a composite material and a coil (5) wound on said magnetic core (4).

2. An antenna for a responder according to claim 1, wherein the composite material comprises layered rectangular metallic thin plates.

3. An antenna (3A; 3B) for a transponder according to claim 2, wherein the corners of said thin plates are cut (a) or rounded (b).

4. An antenna for a transponder according to claims 2 or 3, wherein the thin plates comprise an amorphous magnetic material.

5. An antenna for a transponder according to one or more of the claims 2 to 5, wherein the thickness of the thin plates is 20 to 50 μm.

6. An antenna for a transponder according to one or more of the claims 2 to 5, wherein the number of the layered thin plates is 3 to 16.

7. An antenna for a transponder according to one or more of claims 2 to 6, wherein the thin plates which are insulated by oxidizing their surfaces are layered.

8. An antenna for a transponder according to one or more of the claims 2 to 7, wherein the ratio B/A of the lengths of the side B to the side A of the magnetic core (4) is 1 or, preferably less than 1.

9. An antenna for a transponder according to claim 8, wherein the ratio B/A of the lengths of the shroter side B to the longer side A is 0.4 to 1.0.

10. An antenna for a transponder according to one or more of the claims 2 to 9, wherein the thickness of the antenna is 0.4 mm or less.

11. An antenna for a transponder according to claim 1, wherein magnetic core is provided as a plate and the composite

material is composed of magnetically soft flakes and a synthetic resin.

12. An antenna for a transponder according to claim 11, wherein the magnetically soft material composing said flakes is selected from pure iron, silicon steel, a permalloy (an Fe-Ni alloy) and an iron/cobalt amorphous alloy.

13. An antenna for a transponder according to claim 12, wherein the magnetically soft material composing said flakes is a cobalt amorphous alloy (Co-Fe-Ni-B-Si).

14. An antenna for a transponder according to one or more of claims 11 to 13, wherein said flake has a thickness of 30 μm or less and a diameter of 50 to 2,000 μm.

15. An antenna for a transponder according to one or more of claims 11 to 14, wherein said flakes have a thickness of 10 μm or less and a diameter of 100 to 1,000 μm.

16. An antenna for a transponder according to one or more of claims 11 to 15, wherein said synthetic resin is selected from the group consisting of the thermoset resins, e.g. epoxy resins, phenol resins, urea resins, unsaturated polyester resins, diacrylphthalate resins, melamine resins, silicone resins, and polyurethane resins; and thermoplastic resins, e.g. polyethylene resins, polypropylene resins, vinyl chloride resins, fluoroplastics, methacrylate resins, polystyrene resins, AS resins, ABS resins, ABA resins, polycarbonate resins, polyacetal resins, and polyimide resins.

17. An antenna for a transponder according to one or more of claims 11 to 16, wherein the amount of said synthetic resin in the composite material is 3 to 50 weight%.

18. An antenna for a transponder according to one or more of claims 11 to 17, wherein said flakes comprise a cobalt base amorphous alloy, whereas said synthetic resin is an epoxy resin, and the amount of said synthetic resin in the composite material is 10 to 40 weight%.

19. An antenna for a transponder according to one or more of claims 11 to 18, wherein said magnetic core has a thickness of 0.3 to 2 mm, and a width and length of 100 mm or less, respectively.

20. An antenna for a transponder according to claim 19, wherein said magnetic core has a thickness of 0.3 to 1 mm, a width of 10 to 25 mm and a length of 60 to 80 mm.

21. An antenna for a transponder according to one or more of the preceding claims, wherein the diameter of the coil conductor is 100 to 200 μm.

22. An antenna for a transponder according to one or more of the preceding claims, wherein said coil is wound on the magnetic core perpendicular to the longer side of the magnetic core.

23. An antenna for a transponder according to one or more of the preceding claims, wherein said antenna for a transponder is suitable to carry as an ID card, a commuter pass or a coupon ticket which operates at a frequency over 100 kHz with said plate magnetic core and at a frequency between 40 kHz and 200 kHz with said magnetic core comprised of layered thin plates.

24. A plate transponder (8; 28) comprising two plate antennas (6, 7; 26, 27) composed of a wound conductor on a magnetic core (4) and an air-core antenna (9; 29) composed of a spirally wound conductor as defined in one or more of the preceding claims.

25. A transponder (8; 28) according to claim 24, wherein axes of said three antennas (6, 7, 9; 26, 27, 29) are oriented to three directions perpendicular to each other.

26. A transponder (8; 28) according to claim 24 or 25, wherein said two plate antennas (6, 7; 26, 27) are provided in the plate transponder (8; 28) so that the axes (X, Y) of said two antennas or coils are perpendicular to each other, and said air-core antenna (9; 29) composed of the spirally wound conductor is provided in the plate transponder (8; 28) so that the axis (Z) thereof is perpendicular to the transponder plate (8; 28).

27. A transponder (12) according to one or more of the claims 24 to 26, wherein a magnetic recording layer such as a magnetic strip (13) is provided on the surface of the transponder (12), and antennas (14) are provided inside the transponder (12).

28. A transponder (12) according to one or more of the claims 24 to 27, wherein a printing is provided on the surface.

29. A transponder according to one or more of the claims 24 to 28, wherein embossment is formed on the sections other than said antennas (14), circuit, and magnetic recording layer.

30. A transponder according to one or more of the claims 24 to 29, wherein said transponder (8; 12; 28) is suitable to be carried as an ID card, a commuter pass or a coupon ticket which operates at a frequency of 40 to 200 kHz.

FIG.1

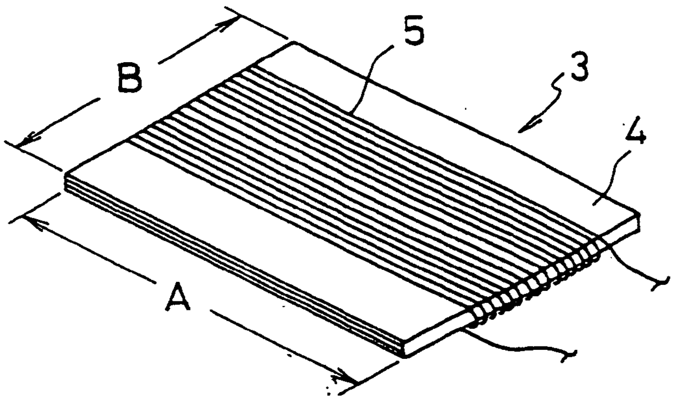


FIG.2A

PRIOR ART

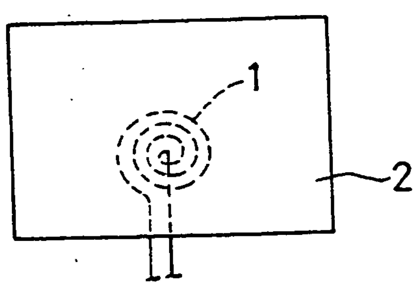


FIG.2B

PRIOR ART

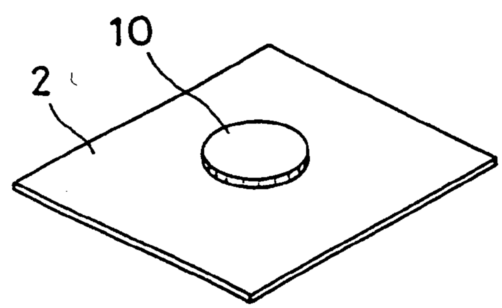


FIG.3A

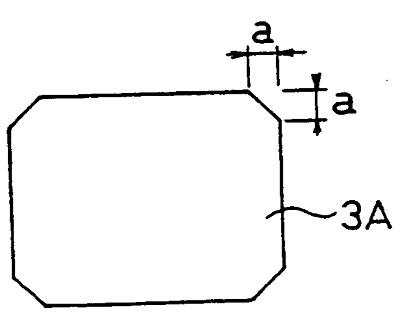


FIG.3B

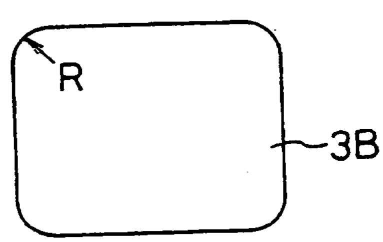


FIG.4A

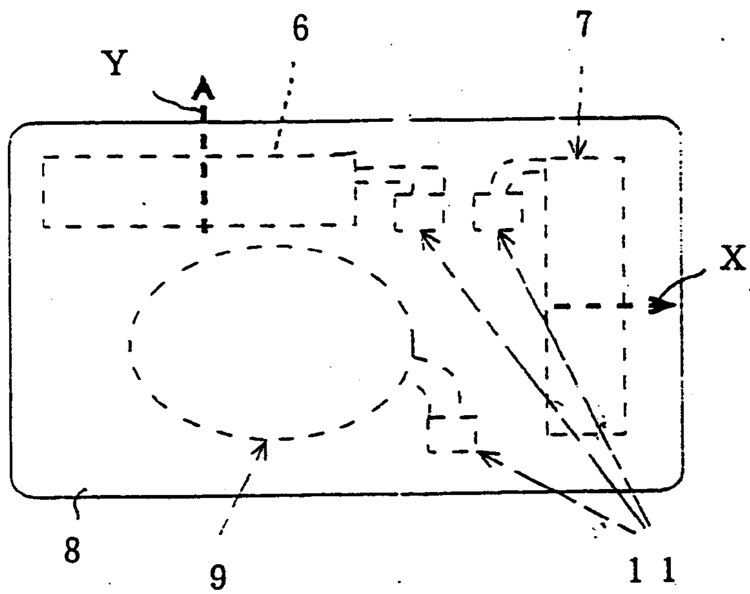
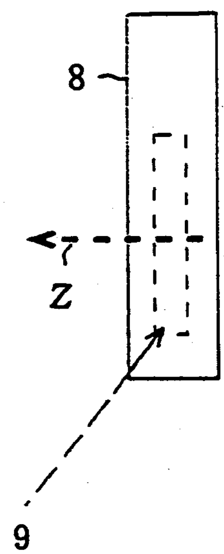


FIG.4B



AXIS DIRECTION OF ANTENNA

FIG.5A

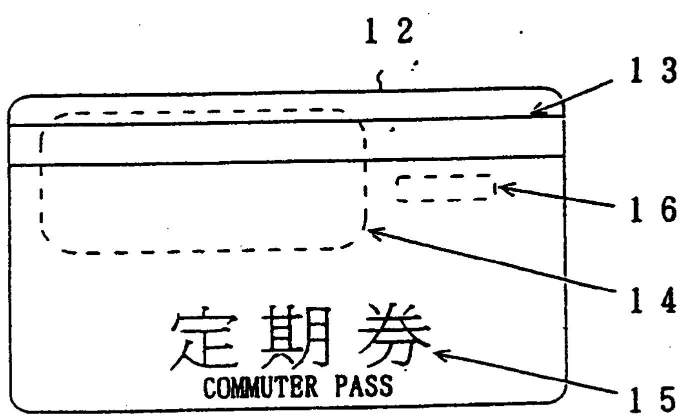


FIG.5B

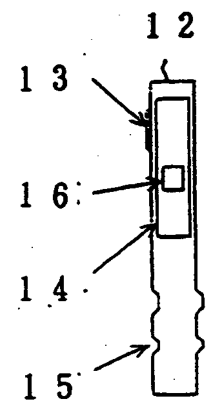


FIG.6A

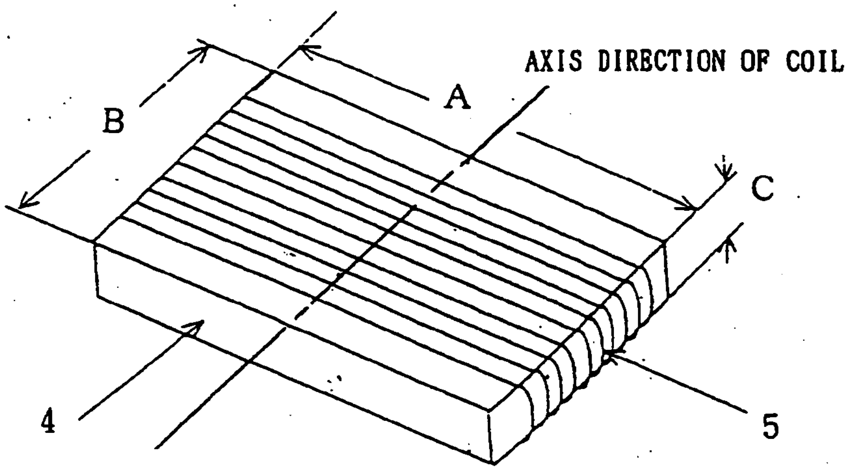


FIG.6B

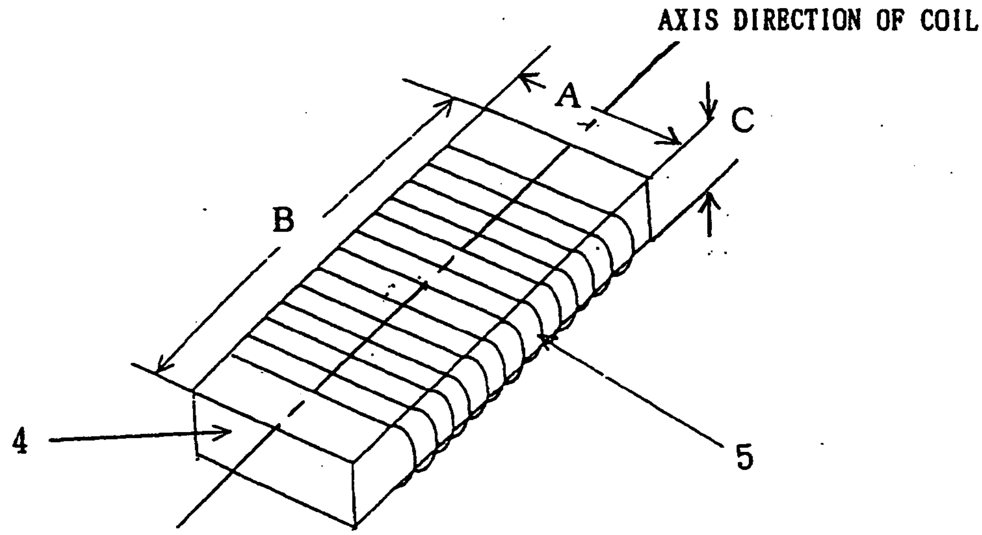


FIG.7A

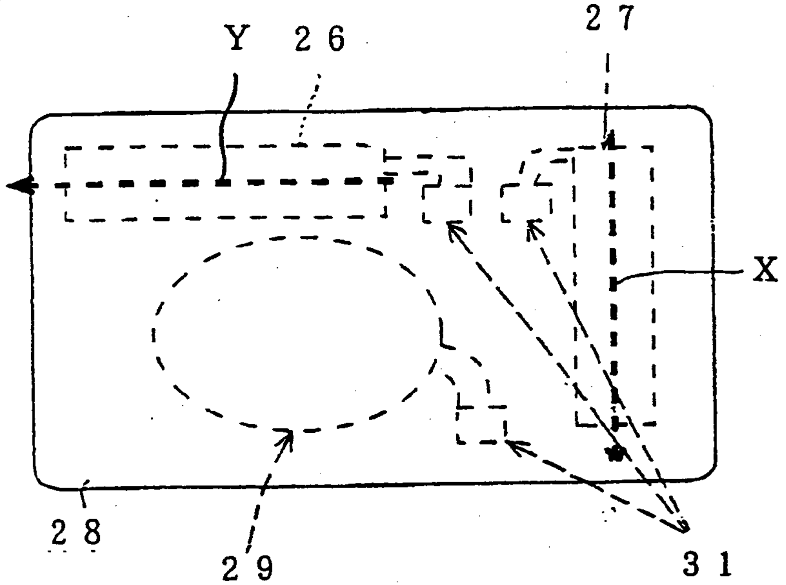
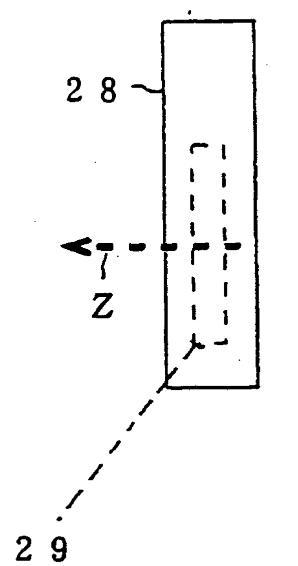


FIG.7B



AXIS DIRECTION OF ANTENNA

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 3479

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-5 396 698 (ORTHMANN KURT ET AL) 14 March 1995 * column 7, line 67 - column 8, line 5; figures 1-18 * * column 8, line 61 - line 65 * * column 6, line 42 * * column 6, line 45 - line 46 * * column 8, line 1-12 *	1,2,4,5, 23	H01Q7/06 H01Q21/28 G01S13/02 H01Q25/00 H01F1/153
Y		11-13,16	

Y	EP-A-0 302 355 (HITACHI METALS LTD) 8 February 1989 * page 1, line 40 - line 42 * * page 6, line 43 - line 47 *	11-13,16	

Y	PATENT ABSTRACTS OF JAPAN vol. 016, no. 324 (E-1234), 15 July 1992 & JP-A-04 094502 (FURUKAWA ELECTRIC CO LTD), 26 March 1992,	11	
	---		TECHNICAL FIELDS SEARCHED (Int.Cl.6)
Y	US-A-5 408 243 (D HONT LOEK) 18 April 1995 * column 2, line 55-62 * * column 3, line 8 - line 12 *	11	H01Q G01S H01F

X	ROTHAMMEL KARL: "ANTENNENBUCH" 1991 , FRANCKH-KOSMOS VERLAG , STUTTGART XP002015822 * page 389 *	24	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	18 December 1996	Johansson, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)